CSC 261/461
Database Systems

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Functional Dependencies

Second Normal Form

- Uses the concepts of *FDs* and *primary key*
- Definitions
  - `Prime attribute`: An attribute that is member of the primary key K
  - `Full functional dependency`: a FD $Y \rightarrow Z$ where removal of any attribute from Y causes FD to not hold any more
  - $X \rightarrow Y$ is a `partial dependency` if some attribute can be removed from X and the dependency still holds
- A relation schema R is in `second normal form` (2NF) if every non-prime attribute A in R is fully functionally dependent on the primary key

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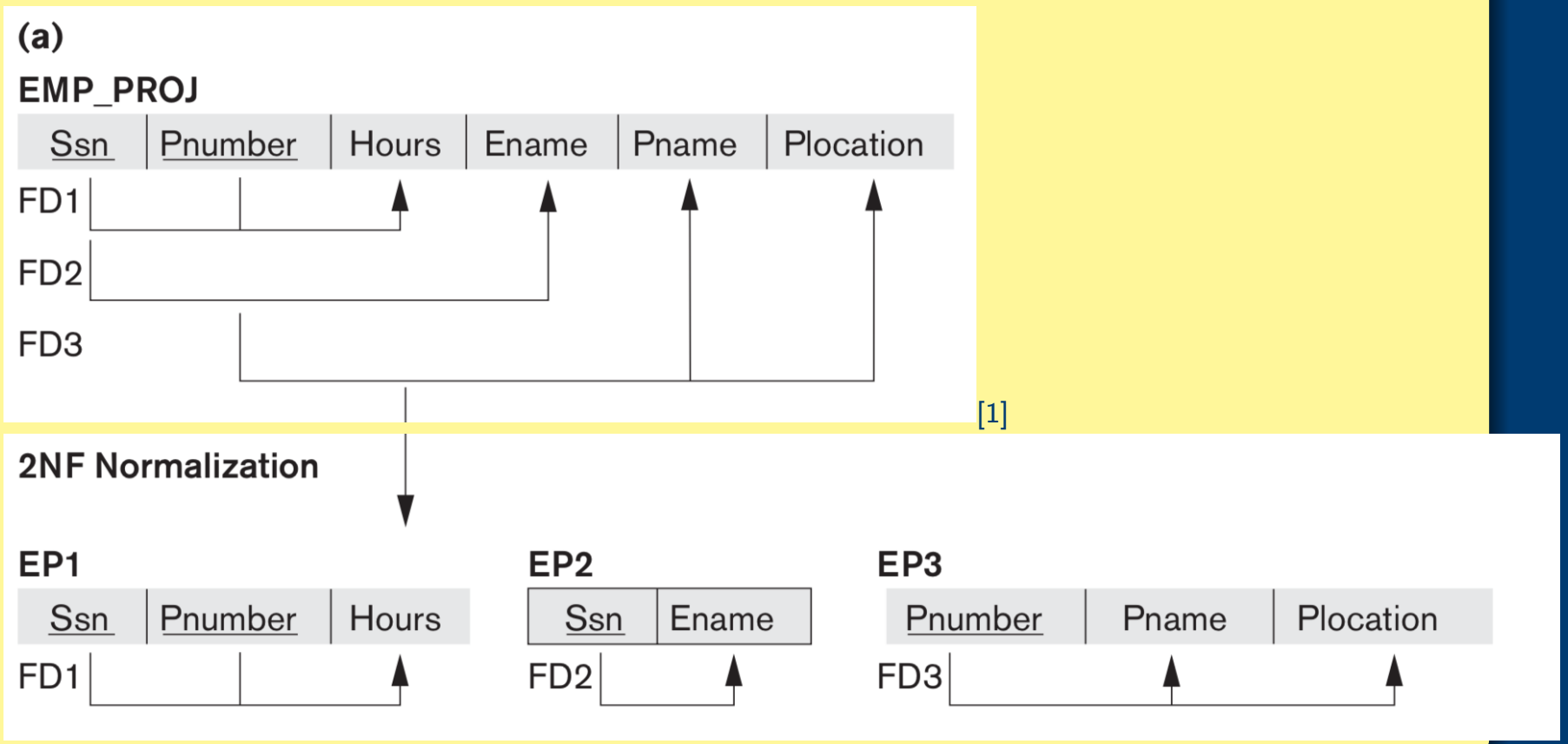
Functional Dependencies

Second Normal Form



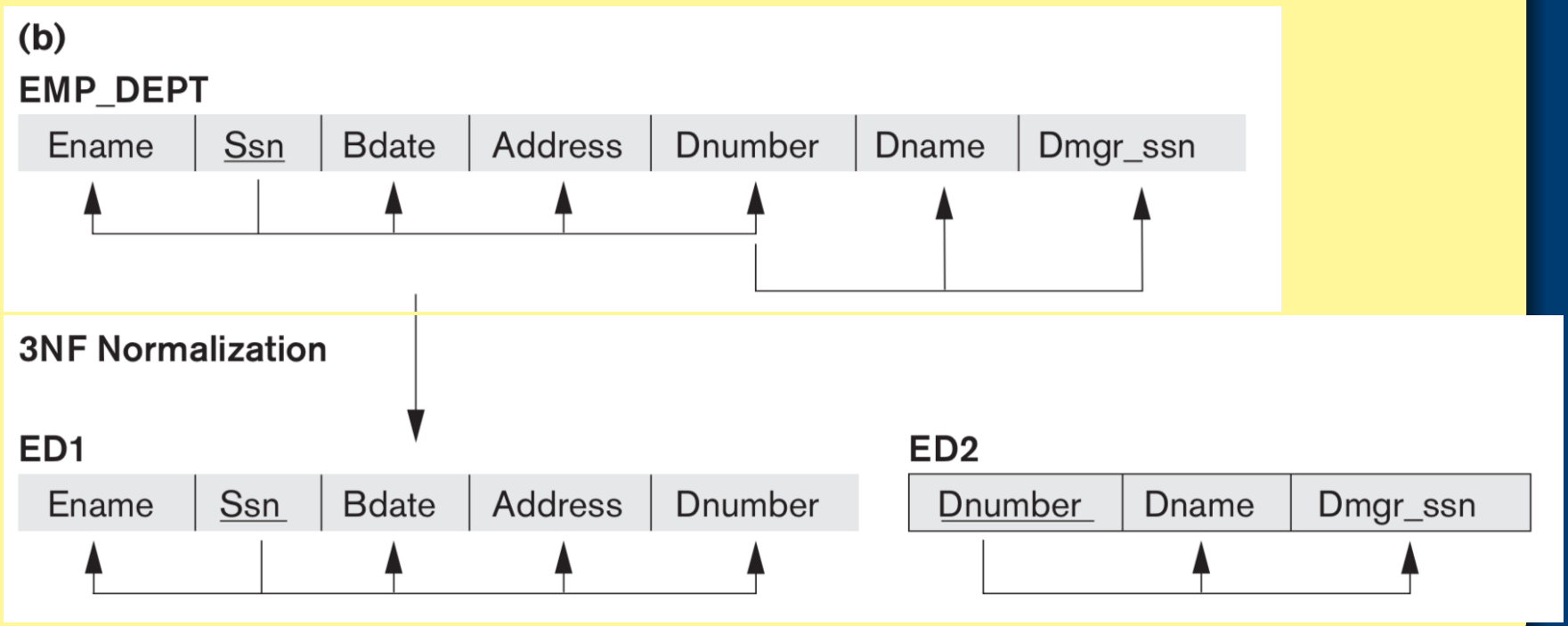
Functional Dependencies

Third Normal Form

- `Transitive functional dependency`: a FD $X \rightarrow Z$ that can be derived from two FDs $X \rightarrow Y$ and $Y \rightarrow Z$
- A relation schema R is in `third normal form` (3NF) if it is in 2NF and no non-prime attribute A in R is transitively dependent on the primary key.

Functional Dependencies

Third Normal Form



Functional Dependencies

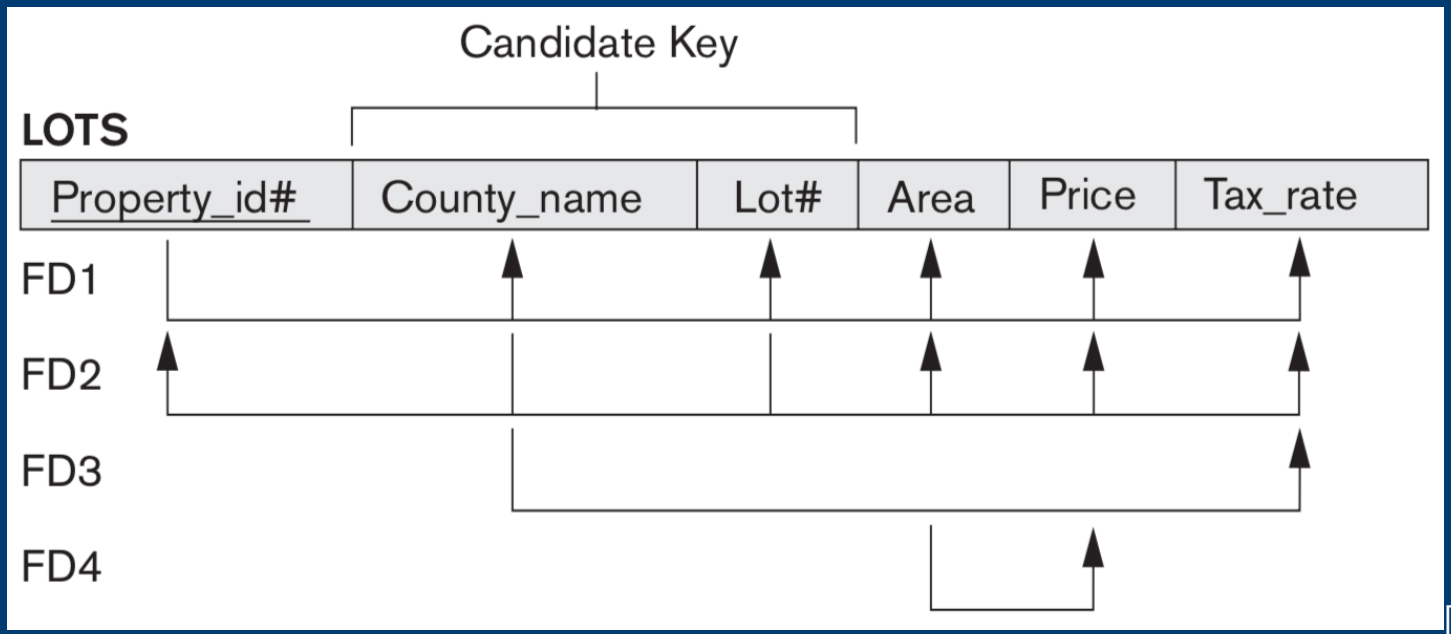
Normal Forms

- `1st` normal form:
  All attributes depend on the key
- `2nd` normal form:
  All attributes depend on the whole key
- `3rd` normal form:
  All attributes depend on nothing but the key

Normal Forms

General Definition of 2NF

A relation schema R is in second normal form (2NF) if every nonprime attribute A in R is not partially dependent on any key of R.



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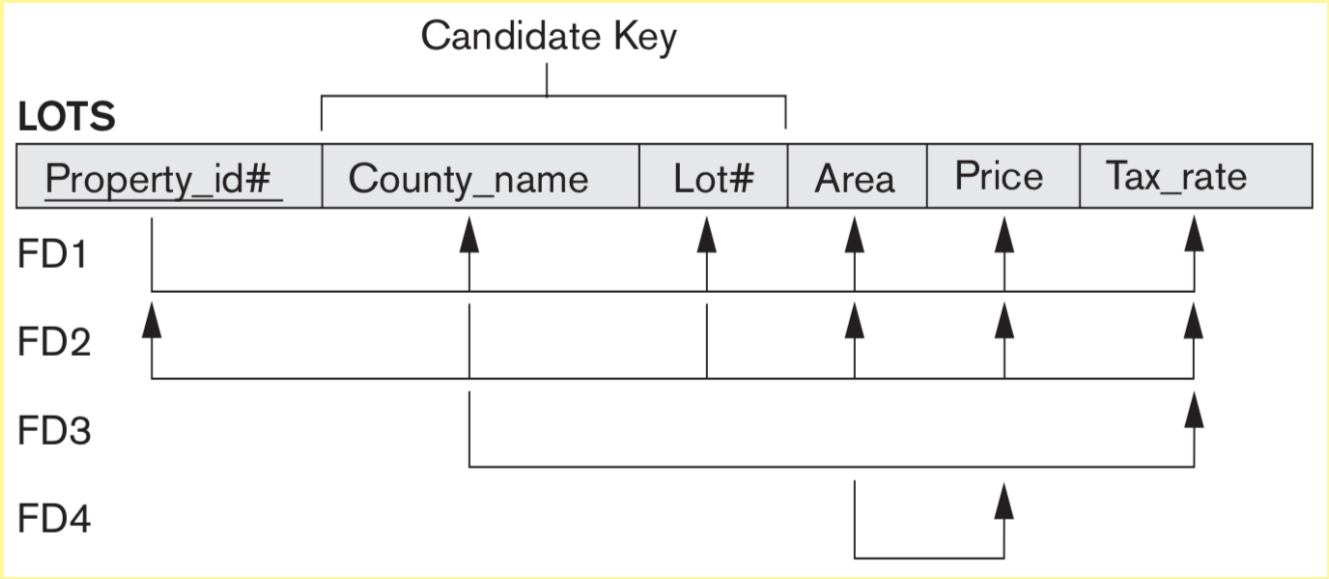
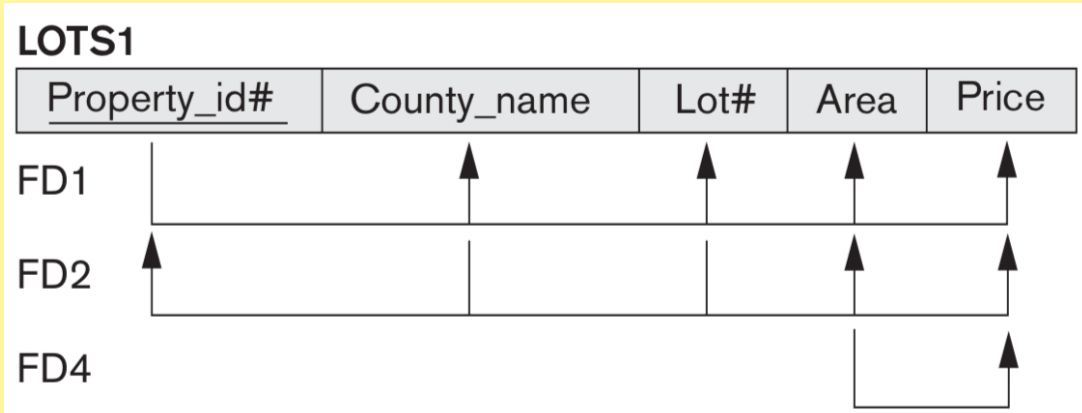
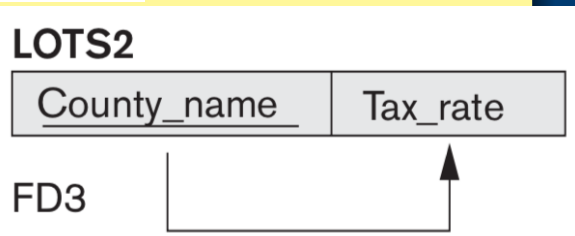
Functional Dependencies

Normal Forms



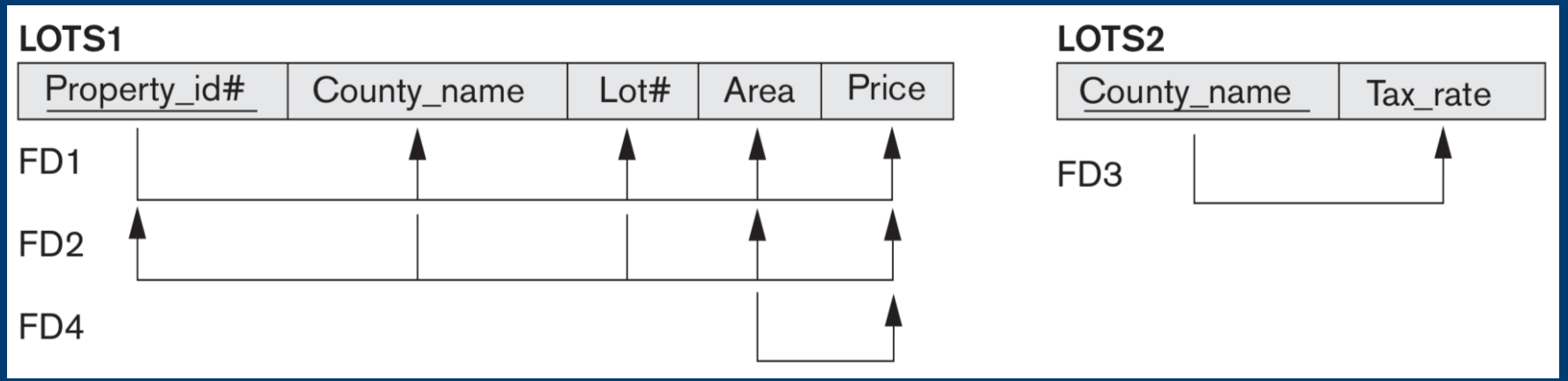




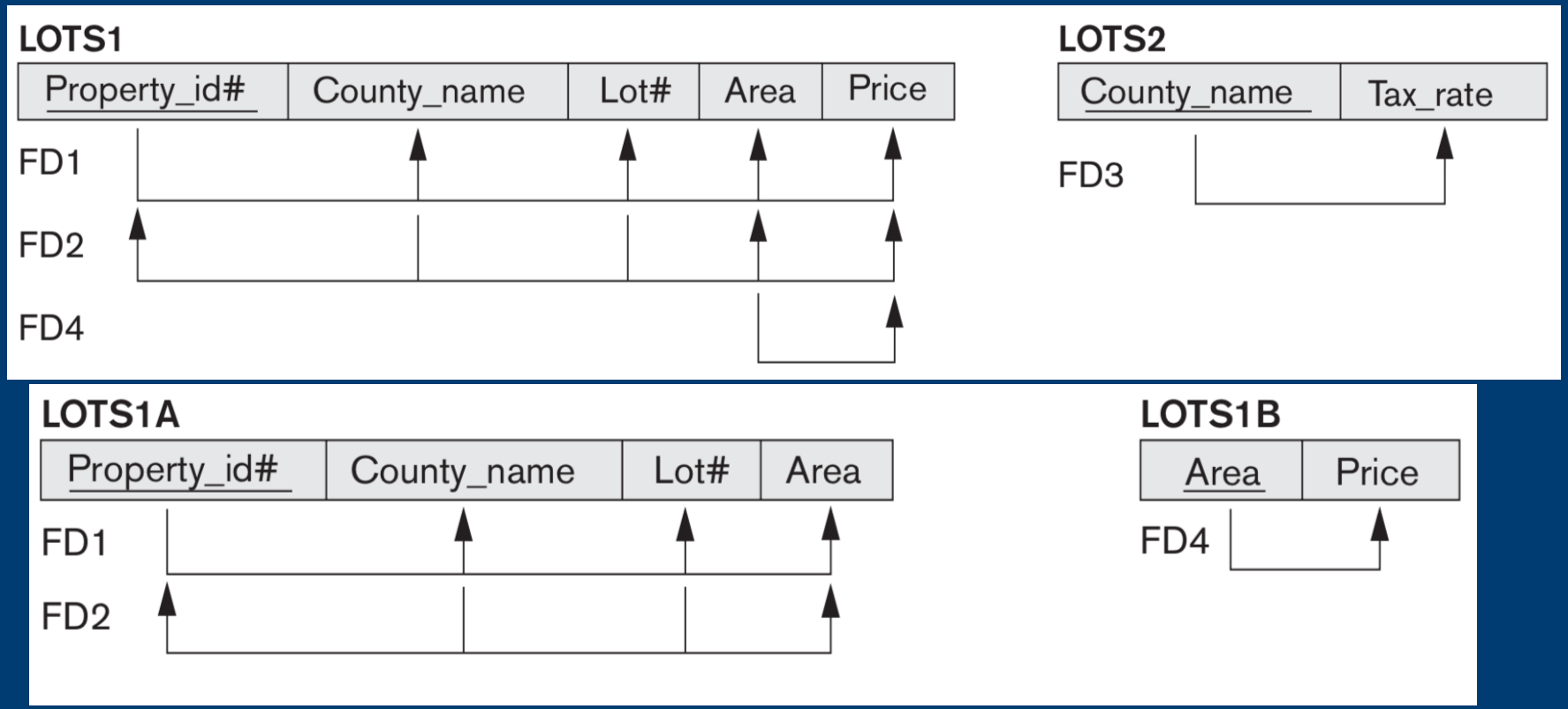
Normal Forms

General Definition of 3NF

A relation schema R is in third normal form (3NF) if, whenever a nontrivial functional dependency $X \rightarrow A$ holds in R, either X is a superkey of R, or A is a prime attribute of R.



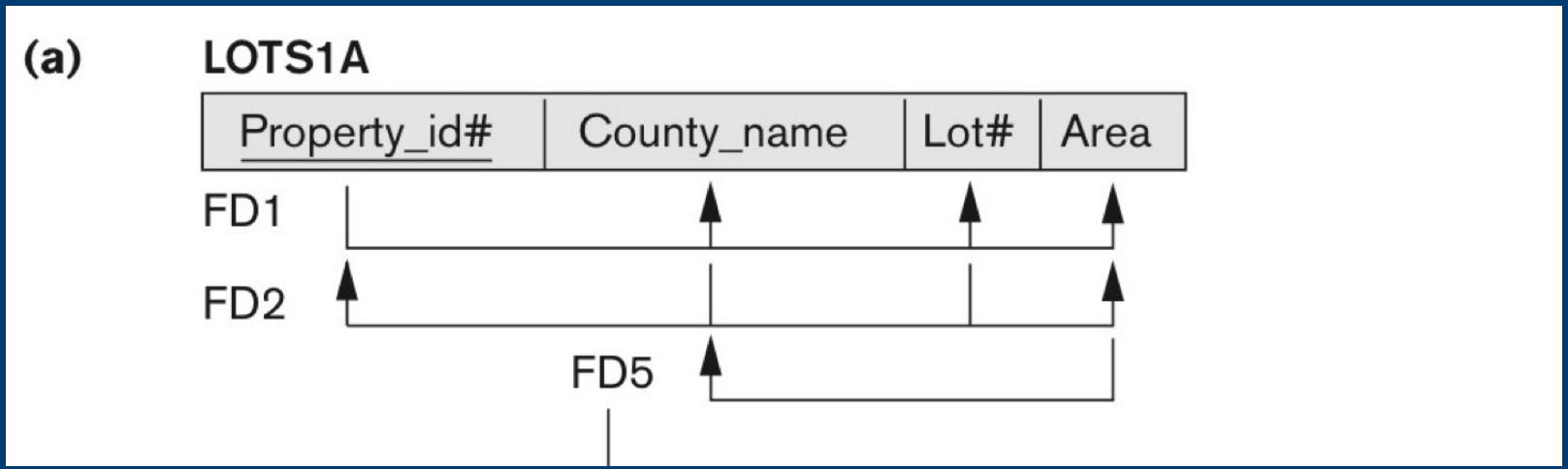
General Definition of 3NF



Normal Forms

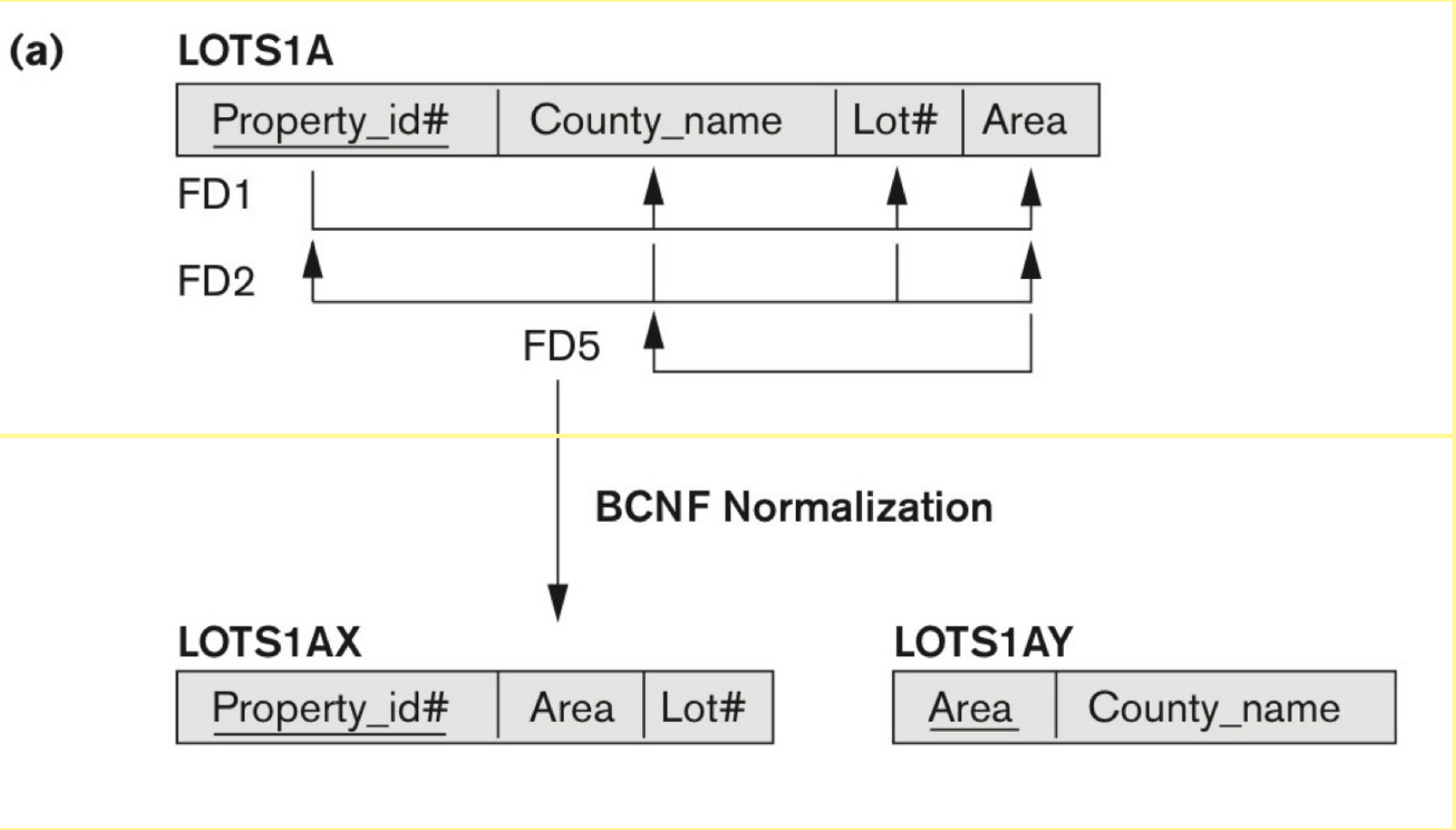
Boyce-Codd Normal Form

A relation schema R is in Boyce-Codd Normal Form (BCNF) if whenever a *nontrivial* FD $X \rightarrow A$ holds in R, then X is a superkey of R



Normal Forms

Boyce-Codd Normal Form

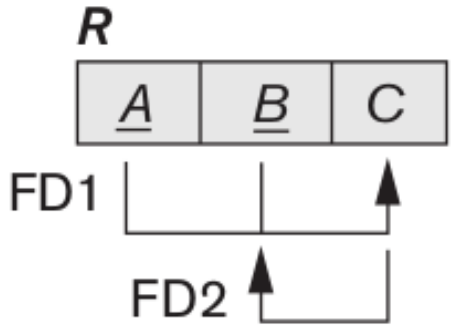


Normal Forms

Boyce-Codd Normal Form

TEACH

Student	Course	Instructor
Narayan	Database	Mark
Smith	Database	Navathe
Smith	Operating Systems	Ammar
Smith	Theory	Schulman
Wallace	Database	Mark
Wallace	Operating Systems	Ahamad
Wong	Database	Omiecinski
Zelaya	Database	Navathe
Narayan	Operating Systems	Ammar



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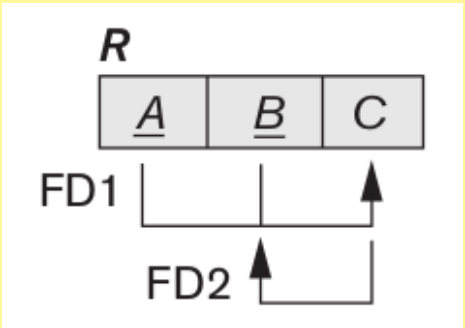
Normal Forms

Boyce-Codd Normal Form

FD1: $\{Student, Course\} \rightarrow Instructor$

FD2: $Instructor \rightarrow Course$



1. R1(Student, Instructor) and R2(Student, Course)
2. R1(Course, Instructor) and R2(Course, Student)
3. R1(Instructor, Course) and R2(Instructor, Student)

Decomposition

FD1: $\{Student, Course\} \rightarrow Instructor$
FD2: $Instructor \rightarrow Course$

1. R1(Student, Instructor) and R2(Student, Course)
2. R1(Course, Instructor) and R2(Course, Student)
3. R1(Instructor, Course) and R2(Instructor, Student)

NJB (Nonadditive Join Test for Binary Decompositions)

A decomposition $D = \{R_1, R_2\}$ of R has the *lossless* (nonadditive) join property with respect to a set of functional dependencies F on R if and only if either

- The FD $((R_1 \cap R_2) \rightarrow (R_1 - R_2))$ is in F^+, or
- The FD $((R_1 \cap R_2) \rightarrow (R_2 - R_1))$ is in F^+